LIQUID-CRYSTAL DISPLAY AND ELEMENT SUBSTRATE THEREOF

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a Continuation-In-Part of pending U.S. patent application Ser. No. 14/493,173, filed Sep. 22, 2014 and entitled "liquid-crystal display and element substrate thereof, which claims priority of Taiwan Patent Application No. 103124494, filed on Jul. 17, 2014, the entirety of which is incorporated by reference herein.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a liquid-crystal display, and in particular to a liquid-crystal display having at least one contact hole.

Description of the Related Art

In a liquid-crystal display, a contact hole is utilized to conduct a pixel electrode and a source electrode. However, with reference to FIG. **1**, the liquid-crystal molecules **2** are arranged along a profile of the contact hole **1**. The contact hole **1** is like a funnel structure, and light leakage in dark state happens due to the liquid-crystal molecules **2** arranged along the profile of the contact hole **1**, and the contrast ratio of the liquid-crystal display is decreased.

With reference to FIG. **1**, conventionally, an area of the source electrode **3** at the bottom the contact hole **1** is increased to cover the light-leaking liquid-crystal molecules **2**, and to improve the contrast ratio of the liquid-crystal display. However, this method decreases the aperture ratio and the transmittance in bright state of the liquid-crystal display, and an improved solution is required.

BRIEF SUMMARY OF THE INVENTION

In one embodiment of the invention, an element substrate is provided, which includes a substrate, a metal layer and a planarization layer. The metal layer is disposed on the substrate, wherein the metal layer has a first width along a first direction. The planarization layer is disposed on the metal layer and having a first thickness along a second direction perpendicular to the first direction, wherein the planarization layer comprises a top and a bottom, and the first thickness is a distance between the top and the bottom along the second direction in a pixel region. The planarization layer comprises a contact hole, the contact hole has a contiguous wall and a hole bottom, the hole bottom exposes the metal layer, and the hole bottom of the contact hole has a second width along the first direction, wherein the first width and the second width satisfy the following equation:

$$2*\left\{\frac{L_2}{2}+\frac{(1-p)h}{\ln(p)\cdot\tan(1.5\theta)}\cdot\ln\left[\frac{-\tan\delta*(1-p)}{\ln(p)\cdot\tan(1.5\theta)}\right]\right\}-3.8\le L_1\le 2*\left\{\frac{L_2}{2}+\frac{(1-p)h}{\ln(p)\cdot\tan(1.5\theta)}\cdot\ln\left[\frac{-\tan\delta*(1-p)}{\ln(p)\cdot\tan(1.5\theta)}\right]\right\}+3.8$$

wherein L_1 is the first width, and L_2 is the second width, h is the first thickness, δ is an angle between 5 degrees to 20 degrees, θ is an included angle between a straight line and an extension surface of the hole bottom, and the straight line connects a reference point and a base point, and the reference point and the base point are located on the contiguous wall, wherein a distance from the reference point to the bottom of the planarization layer along the second direction is 0.95 h. The base point is located at the point where the contiguous wall is connected to the hole bottom, p is an adjustable parameter, and $0<p\le 0.1$.

Utilizing the embodiment of the invention, the aperture ratio and the contrast ratio of the liquid-crystal display are optimized.

A detailed description is given in the following embodiments with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention can be more fully understood by reading the subsequent detailed description and examples with references made to the accompanying drawings, wherein:

FIG. **1** shows an element substrate of a conventional liquid-crystal display;

FIG. **2**A shows cross-section structure of an element substrate of one embodiment of the invention;

FIG. **2**B shows cross-section structure of an element substrate of another one embodiment of the invention;

FIG. **2**C shows cross-section structure of an element substrate of another one embodiment of the invention;

FIG. **3**A shows top-view of the element substrate of the embodiment of the invention utilized in a liquid-crystal display;

FIG. **3**B shows top-view of the structure of portion **3**B of FIG. **3**A in detail;

FIG. **3**C shows top-view of the detailed structures of another one embodiment;

FIG. **4** shows cross-section structure of the element substrate of another one embodiment of the invention;

FIG. **5** shows cross-section structure of a liquid-crystal display of one embodiment of the invention; and

DETAILED DESCRIPTION OF THE INVENTION

The following description is of the best-contemplated mode of carrying out the invention. This description is made for the purpose of illustrating the general principles of the invention and should not be taken in a limiting sense. The scope of the invention is best determined by reference to the appended claims.

FIG. **2**A shows an element substrate **100** of an embodiment of the invention, which comprises a substrate **110**, a metal layer **120** and a planarization layer **130**. The metal layer **120** is disposed on the substrate **110**, wherein the metal layer **120** has a first width L1 along a first direction X. The extending direction of scan lines of the element substrate **100** is parallel to the first direction X. The planarization layer **130** is disposed on the metal layer **120** and has a first thickness h along a second direction Z, the second direction Z is perpendicular to the first direction X, and the second direction Z represent as a normal vector (vertical) of the element substrate **100**. The planarization layer **130** comprises a top and a bottom, and the first thickness h is a distance between the top and the bottom along the second direction Z in a pixel region (PXR), the pixel region locates adjacent to a contact region (CTR) where the contact hole **131** is formed. The planarization layer **130** comprises a contact hole **131**, the contact hole **131** is formed through the planarization layer **130**, the contact hole **131** has a contiguous wall **132** and a hole bottom **133**, the hole bottom **133**